H. Maheswari DEVI* & P. V. S. N. G. Krishnam RAJU**: **Life history of *Portlandia grandiflora* L. (Rubiaceae)**

H. M. デビ*・P. V. S. N. G. K. ラジュ**: *Portlandia grandiflora* L. (アカネ科) の胚学的研究

Portlandia grandiflora L. belongs to the tribe Condamineae of the subfamily Cinchonoideae of Rubiaceae (Schumann 1891). Inspite of the extensive embryological studies in the family the tribe remains uninvestigated. Therefore, it is planned to work out the life history of *Portlandia grandiflora*, the only species of the genus available in India. It, a native of West India, is introduced to India as an ornamental plant for its grand showy flowers. It has bitter stomachic and tonic bark.

Material and methods The material collected at Indian Botanical Garden, Howrah, was fixed in formalin acetic-alcohol. Customary methods of dehydration, infiltration and embedding were followed (Johansen, 1940). Sections cut at 5 to 15 μm thickness were stained with Delafield's haematoxylin.

Observations External morphology. The plant is a perennial shrub of 10–14 feet heigh with elliptic-lanceolate leaves. The solitary flowers are large with about five inches long white corolla. At the throat of the corolla towards inside the colour is somewhat reddish. The normal formula is $K(5)C(5)A5\underline{\bar{G}}(2)$ (Fig. 1A). However, in about 17% of the cases teratological variations occur. Three different conditions of floral formulae—$K(6)C(6)A5\underline{\bar{G}}(2)$, $K(5)C(6)A(6)\underline{\bar{G}}(2)$ (Fig. 1B) and $K(6)C(6)A6\underline{\bar{G}}(2)$ (Fig. 1C) each in about 5.7% of flowers are noticed.

Microsporangium, microsporogenesis and male gametophyte. The anther is tetrasporangiate. During development of anther wall the primary parietal layer gives rise to the inner tapetal layer and outer secondary parietal layer. The latter divides periclinally and produces the middle layer and the hypodermal layer (Fig. 1D). During further development of the anther, both the middle layer and hypodermal layer divide periclinally producing 4-6 layers (Fig. 1E-G). The secretory tapetum shows dual origin. Towards the periphery it is parietal

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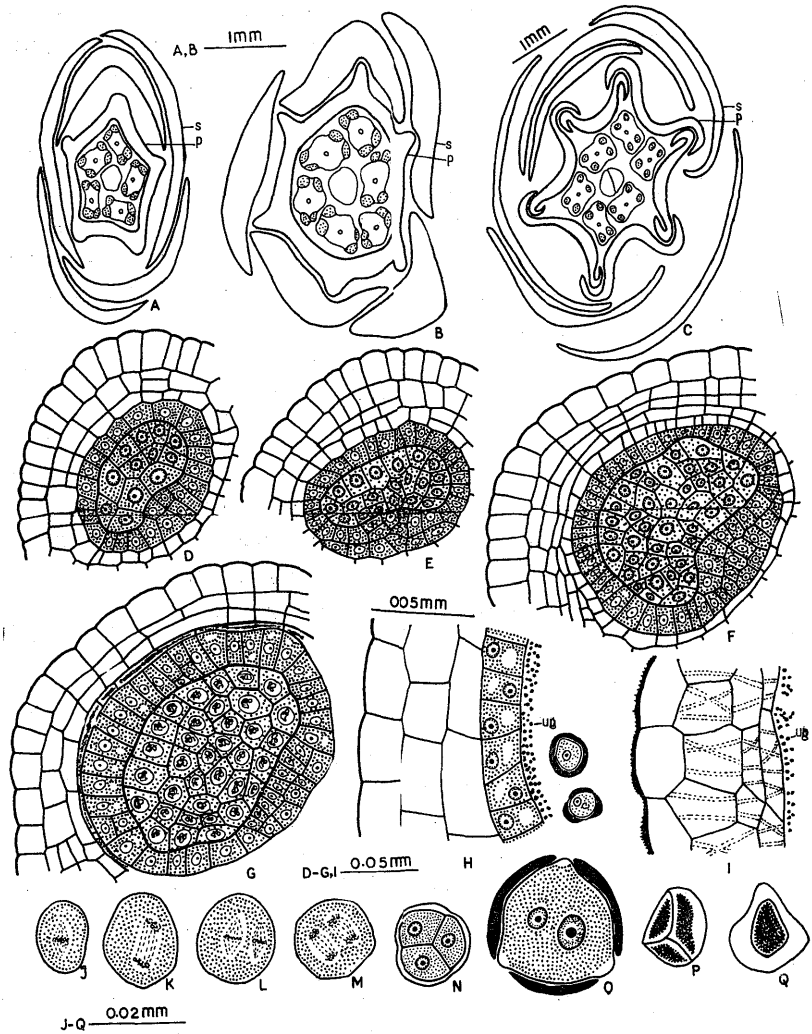


Fig. 1A-Q. A-C: Flowers in Transverse section showing numerical variation of members of whorls. D-F: Transverse section of anther lobes showing wall layers and sporogenous tissue. G: Transverse section of anther lobe showing wall layers (middle layers degenerating) and pollen mother cells (in Prophase I). H: Transverse section of part of anther lobe showing epidermis, endothecial layers, tapetum, 'Ubisch' granules and uninucleate pollen grains. I: Transverse section of part of anther lobe showing persistant epidermis, multilayered fibrous endothecium and 'Ubisch' granules. J-M: Pollen mother cells in meiotic division. N: Pollen tetrad. O: Mature 2-nucleate pollen grain. P: Degenerating pollen tetrad. Q: Degenerating pollen grain. p, petal; s, sepal; ug, 'Ubisch' granules.

and towards inside it is developed from the already existing cells of the connective forming the 'C' tapetum, while the peripheral tapetum remains uniseriate the 'C' tapetum becomes 2-4 layered. It shows slight projection towards the sporogenous tissue making the latter slightly curved (Fig. 1D-G). Its cells remain uninucleate throughout. After completion of the meiosis in pollen mother cells small globular bodies—the 'Ubisch' bodies—develop on the inner walls of the tapetal cells (Fig. 1H). Meanwhile the middle layers degenerate leaving 2-3 hypodermal layers which develop fibrous thickenings to form the multilayered fibrous endothecium. After complete autolysis of the tapetum the 'Ubisch' bodies tend to lie on the inner walls of the inner most layer of the fibrous endothecium (Fig. 1I). By this time the epidermal cells of the anther become enlarged. The outer walls of these cells become thick and show tiny projections (Fig. 1I).

The sporogenous cells undergo a few mitotic divisions to form a moderate mass of pollen mother cells (Fig. 1D). Simultaneous cytokinesis in them result in tetrahedral pollen tetrads (Fig. 1J-N). The mature pollen grains are spherical, binucleate and tricolporate with a thick smooth exine (Fig. 1O). Degeneration of sporogenous tissue and pollen is common (Fig. 1P, Q).

Megasporangium, megasporogenesis and female gametophyte. The ovary is inferior, bicarpellary syncarpous and bilocular with numerous ovules on swollen axile placentation (Fig. 2A). The ovule is anatropous and unitegmic. The nucellus consists of a single layer of epidermal cells surrounding the archesporial cell and conforms to the Phyllis type of Fagerlind (1937) (Fig. 2C). The integument becomes massive and makes the embryo sac deep seated (Fig. 2B). At the megaspore tetrad stage an integumentary tapetum is differentiated (Fig. 2D). At the 8-nucleate embryo sac stage the chalazal portion of the integumentary tapetum degenerates and the micropylar part remains persistant (Fig. 2E-H). It is uniseriate with uninucleate cells. But in a few cases it becomes biseriate (Fig. 2F). The archesporial cell directly develops into the megaspore mother cell which as a result of meiosis gives rise to a linear tetrad of megaspores. Rately, two juxtaposed linear tetrads are encountered (Fig. 2D). The chalazal megaspore of the tetrad is functional and produces an 8-nucleate embryo sac of the Polygonum type (Fig. 2E-G). The synergids are pear shapred. The polars meet near the egg apparatus. The three uninucleate antipodals are ephemeral.

Fertilization. Fertilization is porogamous. The pollen tube enters the em-

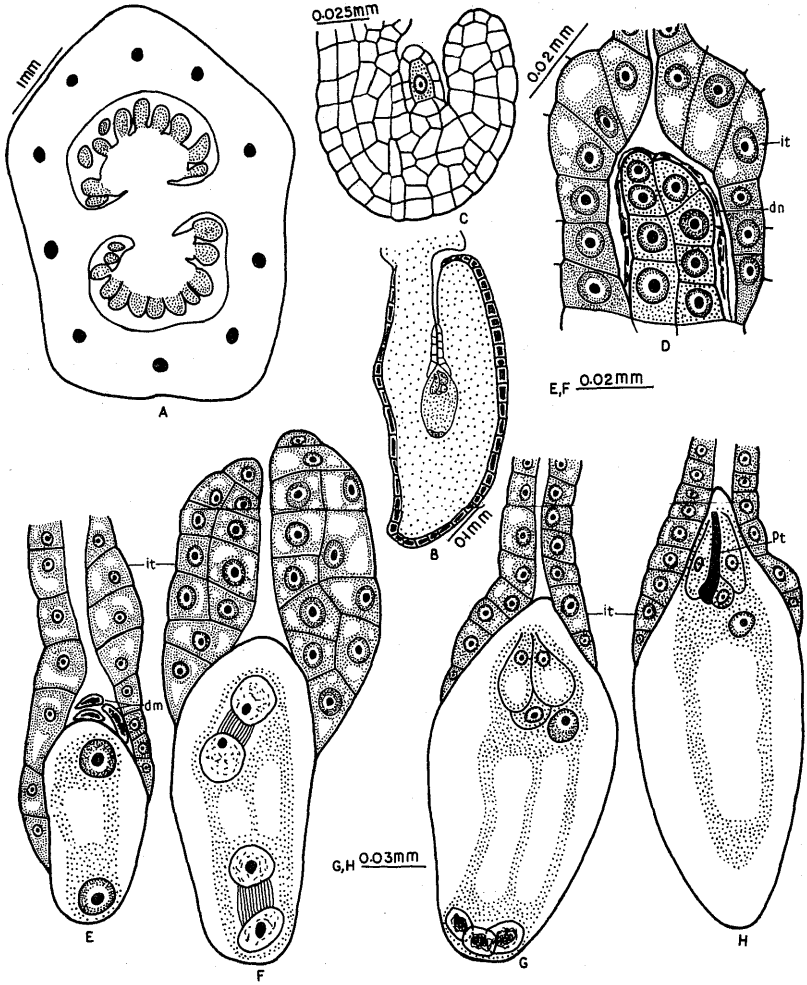


Fig. 2A-H. A: Transverse section of ovary, B: Longitudinal section of ovule showing mature embryo sac. C: Longitudinal section of ovule showing archesporial cell. D: Twin megaspore tetrads. Note the integumentary tapetum and degenerating nucellus. E-G: Stages in the development of embryo sac. Note the integumentary tapetum at the micropylar side. H: Embryo sac after syngamy and triple fusion showing pollen tube. dm, degenerating megaspores; dn, degenerating nucellus; it, integumentary tapetum; pt, pollen tube.

bryo sac without destroying either of the synergids (Fig. 2H). Syngamy and triple fusion occur almost simultaneously.

Endosperm. The development of the endosperm is of Nuclear type. The primary endosperm nucleus divides earlier than the zygote. After formation of considerable free nuclei wall formation commences from the micropylar region and proceeds towards the chalaza making the entire endosperm cellular (Fig. 3A, B). The endosperm cells accumulate abundant reserve food materials (Figs. 3C; 4C).

Embryogeny. The zygote (Fig. 3D) divides transversely to produce the two cells *ca* and *cb*. As a result of transverse division in each of the cells *ca* and *cb*, a linear 4-celled proembryo is formed (Fig. 3E). The cells are termed as *l*, *l'*, *m* and *ci*. The two cells *l* and *l'* undergo each one more transverse division resulting in l_1, l_2, l'_1 and l'_2. Meanwhile the cells *m* and *ci* also divide transversely to produce *d*, *f*, *n* and *n'*. Thus a filamentous eight celled linear embryo is formed (Fig. 3F). The cells l_1 and l_2 divide vertically twice resulting in quadrants in each tier (Fig. 3G). Later the cell l'_1 as result of two vertical divisions at right angles to each other produces quadrants (Fig. 3H). The derivatives of l_1 give rise to cotyledons and stem tip and those of l_2 to the hypocotyledonary region and a part of root. The derivatives of l'_1 contribute to the remaining part of the root. The cells l'_2, *d*, *f*, *n* and *n'* take part in the formation of an uniseriate suspensor (Fig. 3I, J).

Thus the embryo proper develops from the derivatives of the terminal cell *ca* and this is characteristic of Solanad type. Further the proembryo at the third cell generation consists of eight cells arranged in eight tiers and thus keys out to the Physalis I variation.

Seed coat. The seed is wedge shaped and endospermic. The integument at the megaspore mother cell stage is 3–5 cells thick with abundant cytoplasm and healthy nuclei (Fig. 2C). At mature embryosac stage it becomes 10–14 layered the cytoplasm of the cells becomes sparse, and the nuclei begin to degenerate in the outer epidermal cells where globular tannin bodies make their appearance (Fig. 4A). After fertilization, simultaneous with the growth of the young embryo the cells of the integument divide rapidly resulting in quantitative increase. By the time globular embryo is formed, it begins to degenerate and finally all the layers but the outer epidermis become crushed (Fig. 4B, C). The tannin globules in the epidermal cells increase and coalesce with one another

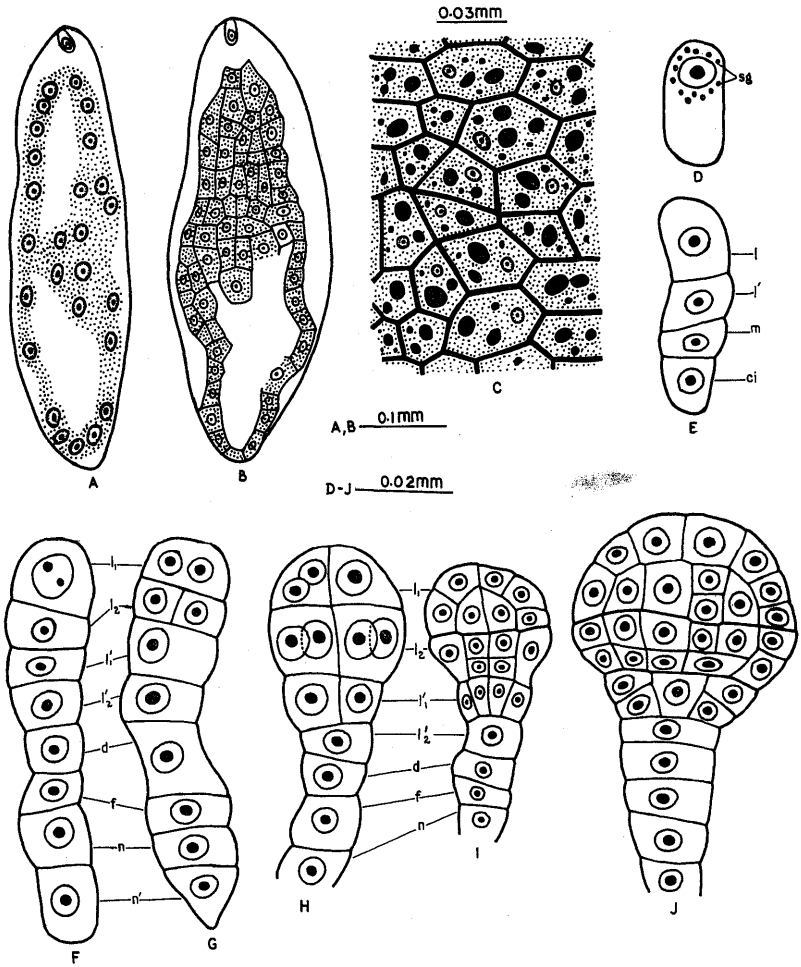
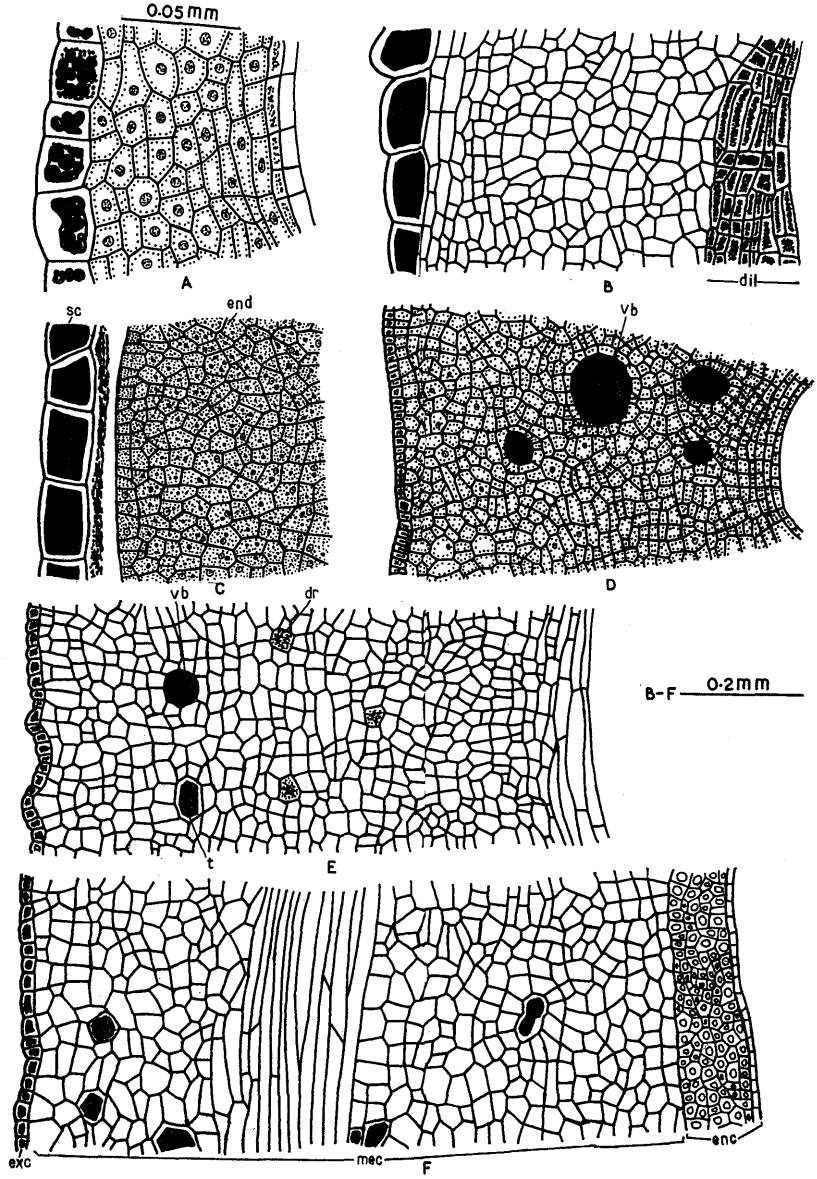


Fig. 3A–J. A: Embryo sac with zygote and Nuclear endosperm. B: Embryo sac with zygote and cellular endosperm. C: A part of cellular endosperm enlarged. Note storage products in the cells. D–J: Different stages in the development of embryo. sg, starch grains.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and the cells are filled with tannin. Thus the tanniferous outer epidermis alone forms the seed coat (Fig. 4C).

Fruit wall. The ovary wall at the megaspore mother cell stage consists of 30-35 layers of parenchymatous cells (Fig. 4D). By the time mature embryo sac is formed, the ovary wall increases further, in its size due to increase in the number of wall layers and also volume of the cells. Calcium oxalate crystals (druses) are present along with silicon crystals. The cells of the epidermal layer accumulate tannin contents (Fig. 4E). After fertilization, increase in the number of wall layers of the ovary is more and by the time a dicot embryo is formed it consists of 40-50 layers. At this stage it can be distinguished into three zones—the outer exocarp represented by tannin filled epidermal layer, the middle mesocarp of somewhat larger cells and the inner endocarp consisting of 6-10 layers of small sclerified cells. The fruit wall is massive (Fig. 4F).

Discussion

In general in Rubiaceae, the anther wall development follows the dicotyledonous type of Davis (1966). However, in *Portlandia grandiflora* increase in the number of middle layers and fibrous endothecium occurs as in *Fadogia cientowskii* (Andronova 1972) and *Anotis lanafolia* (Ahmed 1978). The tapetum is dimorphic in *P. grandiflora* (present data) as in *Tarenna asiatica* (Periasamy & Parameswaran 1965) and *Morinda tinctoria* (Sivaramaiah, 1975). Farooq (1960) states that the integumentary tapetum may not be present in the Family Rubiaceae. However, its presence in *P. grandiflora* (present data) and *Ophiorrhiza harrisiana* (Gopinath & Chennaveeraiah 1961) indicates that the occurrence of integumentary tapetum may not be a characteristic of the family but is a rare feature.

P. grandiflora resembles the rest of the Rubiaceae in embryological characters such as dicotyledonous type of antherwall, simultaneous cytokinesis of pollen mother cells, unitegmic, tenuinucellate ovule, Polygonum type of embryosac development, nuclear endosperm and Solanad type of embryogeny.

Fig. 4A-F. A: Longitudinal section of integument at mature embryo sac stage. B: Longitudinal section of seed coat and globular embryo stage. C: Longitudinal section of mature seed coat and a part of endosperm. D-E: Transverse section of ovary wall at megaspore mother cell and mature embryo sac stage respectively. F: Longitudinal section of mature fruit wall. dil, degenerating inner layers; dr, druse; enc, endocarp; end, endosperm; exc, exocarp; mec, mesocarp; sc, seed coat; t, tannin; vb, vascular bundle.

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西インド諸島原産でアカネ科キナノキ亜科に属し，観賞植物として栽培される *Portlandia grandiflora* L. の花粉，胚嚢，胚乳，胚形成を報告した。他のアカネ科植物とほぼ同じで，花粉壁の出来方は dicotyledonous type である。胚珠は1枚の珠皮をもち，薄層珠心である。胚嚢形成は Polygonum type，胚乳形成は nuclear type，胚形成は Solanad type である。